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NUREG-0979
Supplement No. 5

COMPLETED

Safety Evaluation Report

related to the final design approval of the GESSAR II BWR/6 Nuclear Island Design

Docket No. 50-447

General Electric Company

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U.S. Nuclear Regulatory Commission

Office of Nuclear Reactor Regulation

May 1986

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ABSTRACT

Supplement 5 to the Safety Evaluation Report (SER) for the application filed by General Electric Company for the final design approval for the GE BWR/6 nuclear island design (GESSAR II) has been prepared by the Office of Nuclear Reactor Regulation of the Nuclear Regulatory Commission. This report supplements the GESSAR II SER (NUREG-0979) issued in April 1983 summarizing the results of the staff's safety review of the GESSAR II BWR/6 nuclear island design; Supplement 1, issued in July 1983; Supplement 2, issued in November 1984; Supplement 3, issued in January 1985; and Supplement 4, issued in July 1985. Subject to favorable resolution of the items discussed in the Final Design Approval (FDA-1, Amendment 2), the staff concludes that the GESSAR II design satisfactorily addresses the severe-accident concerns described in the Commission's Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants, and that subject to approval of the balance-of-plant design, applicants referencing GESSAR II can conform with the provisions of the Atomic Energy Act of 1954, as amended, and the regulations of the U.S. Nuclear Regulatory Commission.

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TABLE OF CONIENTS

	Page
ABSTRACT	iii
ACRONYMS AND INITIALISMS	vi
1 INTRODUCTION AND GENERAL DISCUSSION	1-1
1.1 Introduction	1-1
1.8 Summary of Outstanding Issues	1-1
1.9 Confirmatory Issues	1-2
1.10 Interface Information	1-2
6 ENGINEERED SAFETY FEATURES	6-1- 3
6.2 Containment Systems	6-1
6.2.5 Combustible Gas Control	6-1
15 TRANSIENT AND ACCIDENT ANALYSIS	15-1-4
15.6 Severe Accidents	15-1
15.6.2 Major Review Results and Conclusions From PRA Review	15-1
15.6.3 Consideration of Potential Design Improvements	15-3-6
22 REPORT OF THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS	22-1-8
APPENDIX A CONTINUATION OF CHRONOLOGY	
APPENDIX E PRINCIPAL STAFF CONTRIBUTORS	
APPENDIX G COMPLIANCE WITH CP/ML RULE (10 CFR 50.34(f))	
APPENDIX H ACRS REPORT RELATED TO THE FINAL DESIGN APPROVAL OF THE GESSAR II BWR/6 NUCLEAR ISLAND DESIGN APPLICABLE TO FUTURE PLANTS	

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ACRONYMS AND INITIALISMS

ACRS	Advisory Committee on Reactor Safeguards
ATWS	anticipated transient without scram
BNL	Brookhaven National Laboratory
BOP	balance of plant
BWR	boiling-water reactor
CP	construction permit
FDA	Final Design Approval
GE	General Electric Co.
GESSAR	General Electric Standard Safety Analysis Report
IGSCC	intergranular stress corrosion cracking
LOCA	loss-of-coolant accident
ML	manufacturing license
NRC	Nuclear Regulatory Commission
NRR	Office of Nuclear Reactor Regulation, NRC
OL	operating license
ORNL	Oak Ridge National Laboratory
PDA	Preliminary Design Approval
PRA	probabilistic risk assessment
PWR	pressurized-water reactor
RCIC	reactor core isolation cooling
RG	Regulatory Guide
RHR	residual heat removal
SER	Safety Evaluation Report
SPDS	safety parameter display system
SSER	Supplement to Safety Evaluation Report
STCP	source term code package
UPPS	ultimate plant protection system
USI	Unresolved Safety Issue

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1 INTRODUCTION AND GENERAL DISUCSSION

1.1 Introduction

On April 8, 1983, the Nuclear Regulatory Commission staff (staff) issued a Safety Evaluation Report (NUREG-0979) regarding the application by General Electric Company (GE) for a Final Design Approval (FDA) for GE's BWR/6 nuclear island design (GE Standard Safety Analysis Report, GESSAR II). In July 1984, Supplement 1 to the Safety Evaluation Report (SSER 1) was issued for GESSAR II, and on July 27, 1983, the Office of Nuclear Reactor Regulation issued FDA-1 for GE's BWR/6 nuclear island design. This approval allows the GESSAR II design to be referenced in operating license (OL) applications for plants that referenced the GESSAR-238 nuclear island design Preliminary Design Approval (PDA-1) at the construction permit (CP) stage of the licensing process. FDA-1 is the first Final Design Approval issued by the Office of Nuclear Reactor Regulation for a standard nuclear plant design or major portion thereof.

SSER 2, SSER 3, and SSER 4 were issued in November 1984, January 1985, and July 1985, respectively. They provide information related to the staff review of GESSAR II for the severe-accident concerns identified in the Commission's Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants (50 FR 32138). The present supplement (SSER 5) provides more recent information regarding resolution or current status of the open and confirmatory items identified in SSER 4. This supplement also provides and discusses the recommendations of the Advisory Committee on Reactor Safeguards (ACRS) in its report on the GESSAR II design as it satisfactorily addresses the Commission's concerns identified in the severe accident policy statement.

Each of the following sections and appendices of this supplement is numbered the same as the SER section or appendix that is being revised, and the discussions are supplementary to and not in lieu of those in the SER unless otherwise noted. Accordingly, Appendix A is a continuation of the chronology of the safety review. Appendix E lists the principal contributors to this supplement. Appendix G provides further discussion of compliance with the CP/ML Rule. Appendix H is a copy of the ACRS letter report of January 14, 1986, on the severe-accident phase of the GE application for a Final Design Approval.

The NRC's Technical Managers for the GESSAR II review are Mr. William B. Hardin and Mr. Mark Rubin. Mr. Hardin and Mr. Rubin are also principal contributors to this supplement. The NRC Licensing Project Manager for GESSAR II is Mr. Dino Scaletti. Mr. Scaletti may be reached by calling him at (301) 492-8208 or by writing to him at the Division of BWR Licensing, Office of Nuclear Reactor Regulation, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555.

1.8 Summary of Outstanding Issues

During the course of the staff review of the GE probabilistic risk assessment (PRA) of the BWR/6 nuclear island described in GESSAR II, issues have been identified that remain unresolved. The unresolved status has been attributable to the fact that (1) the staff needed to review existing information, (2) GE

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needed to supply additional information, or (3) the staff needed to consider the issue further. SSER 4 listed one outstanding issue that was under staff consideration. The issue is relay chatter and it is addressed in Section 15.6.2.3 of this supplement. The GESSAR II FDA will be conditioned to resolve this issue before the staff issues a construction permit or an operating license to a utility referencing the GESSAR II design.

1.9 Confirmatory Issues

SSER 4 listed five confirmatory issues that were either under staff review or were awaiting information or a staff audit to review existing information. The tabulation below shows the current status of each of the six issues.

Issue	Status
RHR and RCIC pool bypass (15.6.2)	Resolved
Software engineering manual	Awaiting staff audit
Optical isolators	Awaiting information
Combustible gas control (6.2.5)	Resolved
SPDS performance evaluation (Appendix G)	Resolved

1.10 Interface Information

GESSAR II describes a standard BWR/6 nuclear island design. Consequently, GESSAR II does not describe an entire facility, but is limited in scope to those design and safety features associated with the nuclear island design. The design scope is defined in the SER and in GESSAR II, Section 1.2. GESSAR II also defines interface requirements that must be imposed on the reference plant (individual applicant referencing GESSAR II) so that the balance of plant (BOP) will provide compatible design features that will ensure the applicability, functional performance, and safe operation of the GESSAR II systems.

A summary of the interface requirements resulting from the staff review of the GESSAR II for severe-accident concerns is presented in Table 1.2 of this supplement. For a complete list of interface requirements, see GESSAR II (Section 1.9) and Table 1.2 of the SER and its supplements.

Table 1.2 Interface items

SER section	Item
15.6.2.3(1.2)	Relay chatter
15.6.2.3(1.5)	Site-specific hazard function analysis
15.6.2.5(8)	Staff report on suppression pool bypass

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6 ENGINEERED SAFETY FEATURES

6.2 Containment Systems

6.2.5 Combustible Gas Control

In SSER 1, the staff indicated that it was reviewing the corrosion rates for aluminum proposed by General Electric Co. (GE) to determine their acceptability for GESSAR II. The aluminum corrosion rates used by the staff (ANS Standard 56.1 (draft 7) and Regulatory Guide (RG) 1.7) were orders of magnitude higher than the values proposed by GE. The latest draft of ANS 56.1 (draft 10) is about to be published and it includes an added statement that "other hydrogen generation rates may be used but shall be justified by experimental data." The corrosion rates proposed by GE are based on experimental values (Frid et al.)* for exposure of aluminum at pH 5, which is representative of boiling-water-reactor (BWR) conditions. Other Oak Ridge National Laboratory (ORNL) experimental data (CD-SET-112, March 1977) under similar conditions are in agreement with the GE data. The aluminum corrosion rate values given in ANS 56.1 and RG 1.7 are applicable for pressurized-water-reactor (PWR) analyses where pH values can exceed 9.0. On the basis of the experimental evidence, the staff concludes that the proposed GE aluminum corrosion rates are both realistic and acceptable for use in the combustible gas analyses.

With resolution of the issue dealing with aluminum corrosion rates, the staff concludes that the GESSAR II combustible gas control system can effectively handle the hydrogen generated from a postulated loss-of-coolant accident (LOCA).

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*W. Frid, G. Karlberg, and S. B. Sundvall, "Hydrogen Generation From Aluminum Corrosion in Reactor Containment Spray Solutions," presented at Second International Workshop on the Impact of Hydrogen on Water Reactor Safety, Albuquerque, New Mexico, October 3-7, 1982. Available from U.S. Government Printing Office (U.S. Nuclear Regulatory Commission, NUREG/CP-0038, pp. 439-450) or from Electric Power Research Institute (EPRI RP 1932-35, pp. 439-450).

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15 TRANSIENT AND ACCIDENT ANALYSIS

15.6 Severe Accidents

15.6.2 Major Review Results and Conclusions From PRA Review

15.6.2.3 External Events

(1.2) Seismic Fragility Analysis

In SSER 3, the staff expressed its concern with relay chatter as a component failure mode. The staff concern is based on studies that suggest that chattering of relays during a seismic event could result in the tripping of numerous systems and components required to respond successfully to the seismic event. In order to resolve the staff's concern and to more fully address the issue of relay chatter, certain information must be provided before the staff issues a construction permit to a utility whose application references GESSAR II. The Final Design Approval (FDA) will be conditioned to require the General Electric Co. (GE) to provide the following information:

(1) Identify all relays that may be affected with respect to type, size, function, and location. Only relays that affect important systems need be considered. For this definition, an important system is a plant component or system called upon to respond to or mitigate a plant transient or accident.

(2) For all above relays, develop fragility values. Provide justification of values chosen, utilizing generic data or component-specific qualification tests.

(3) Develop realistic transfer functions to the ground considering the effect of electrical equipment cabinets, buildings, and for various ranges of soil types.

(4) Considering the impact of relay chatter and the seismic systems analysis modifications made by Brookhaven National Laboratory (BNL), evaluate plant response and recovery following a seismic event. The impact of breaker trips, seal-ins, manual and test switches, and load sequence failure should all be considered. The seismic event trees should be reconstructed reflecting the impact of relay chatter, and dominant seismic sequences should be requantified.

(1.5) Conclusions

In SSER 3 the staff identified certain actions that would be required of utility applicants that reference the GESSAR II design. These actions were determined to be necessary because of the wide range of potential uncertainties associated with the impact of a seismic event. In order to reduce the potential uncertainties from seismic events, the staff has developed additional to replace the three action items identified in SSER 3. These are as follows:

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(1) Perform a site-specific hazard function analysis, and justify that the mean and mean plus one standard deviation of the site-specific hazard are bounded by the mean and mean plus one standard deviation GESSAR II seismic hazard function as indicated in Table 2-3 of the "GESSAR II Seismic Event Uncertainty Analysis," December 1983.

(2) Develop a critical components and structures list for the plant with due consideration of Table 15.1. Perform fragility analyses of all critical structures and components and show that they are bounded by the values presented in the GESSAR II seismic risk study, and clearly indicate all supporting assumptions and calculations incorporated into the fragility analyses. In this context, bounding the fragility value means that the plant-specific median values should be greater than or equal to the GESSAR II median values and that the plant-specific logarithmic standard deviation values should be below or equal to the corresponding GESSAR II values. For critical components not included in the GESSAR II list, an applicant should satisfy the Case 1 alternate fragilities presented in SSER 3 (Table 15.2).

(3) For the balance of plant features not included in the GESSAR II or the Case 1 analysis, and any plant-specific seismic vulnerability to be determined from a plant-specific walkdown, show that the as-built plant satisfies the assumptions utilized by the GESSAR II analysis.

In the event that these analyses indicate that the above conditions are not met, the utility applicant shall demonstrate that this does not result in any significant increase in risk.

15.6.2.5 GESSAR II Risk Findings

(8) Consequences and Risk From Internally Initiated Severe Accident Events

Suppression Pool Bypass

In SSER 4, the staff discussed the importance of accident sequences involving the bypass of the suppression pool with the associated potential for large fission-product releases. It was noted that the staff and its consultant, Brookhaven National Laboratory, were preparing analyses using the new source term code package (STCP) for a residual heat removal (RHR) suction line break and a BWR Event V, and that the results from these analyses would be reported later. Because of the complexities in running the new code package and the complexity of performing these types of analyses, there are still no results to report. Considering the potential for retention of fission products in the primary system and in containment, the staff continues to believe that the results from these additional pool bypass events will not significantly change its conclusions regarding the low risk level associated with the GESSAR II design. The results from these calculations will be reported in the staff's safety evaluation report for the first application referencing the GESSAR II design.

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15.6.3 Consideration of Potential Design Improvements

15.6.3.3 Staff/Consultant Independent Evaluation of Potential Design Modifications

15.6.3.3.4 Assessment of Final Design Features Candidates

Table 15.10 has been revised to correct typographical errors that were present in SSER 4.

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GESSAR II SSER 5
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Table 15.10 Estimated frequency of release categories resulting from seismic events for GESSAR II base case and with design modifications

Release category*	Base case	Base case and perfect hydrogen control	UPPS	UPPS and seismic upgrade	10-hour battery capacity	DC charger generator	UPPS and generator and seismic upgrade	UPPS and seismic upgrade and perfect hydrogen control
1-SB-E1	1.2(-6)**	-	1.2(-6)	1.2(-6)	Same as base case		Same as UPPS and Seismic	-
1-T-L3	3.5(-7)	5.8(-5)	3.2(-7)	1.9(-7)	"	"	"	3.8(-5)
1-S2(max)	6.9(-8)	6.9(-8)	6.9(-8)	6.9(-8)	"	"	"	6.9(-8)
ATWS	5.9(-6)	5.9(-6)	5.9(-6)	5.9(-6)	"	"	"	5.9(-6)
1-T-I2	5.6(-5)	-	4.9(-5)	3.6(-5)	"	"	"	†
V-event	2.3(-7)	2.3(-7)	2.3(-7)	2.3(-7)	"	"	"	2.3(-7)†
RHR pipe break	2.9(-6)	2.9(-6)	2.7(-6)	2.1(-6)	"	"	"	2.2(-6)†
Massive failure	1.4(-7)	1.4(-7)	1.4(-7)	1.4(-7)	"	"	"	1.4(-7)†
TOTAL	6.7(-5)	6.7(-5)	5.9(-5)	4.6(-5)	6.7(-5)	6.7(-5)	4.6(-5)	4.6(-5)

*See Table 15.15 (of SSER 4) for a description of the release categories.
**1.2(-6) = 1.2×10^{-6}.
†Revised from SSER 4.

22 REPORT OF THE ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

During its 309th meeting, held from January 9 through 11, 1986, the Advisory Committee on Reactor Safeguards (ACRS) completed its review of the application of General Electric Company (GE) for a Final Design Approval (FDA) for GESSAR II which satisfactorily addresses the severe-accident concerns described in the Commission's Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants. This application was also considered at ACRS Subcommittee meetings on October 18-19, December 4-5, 1984, and February 14-15, 1985, in Los Angeles, California; on March 27-29, 1985, in Albuquerque, New Mexico; and on August 7 and September 11, 1985, in Washington, D.C. The full Committee considered this matter during its 299th through 309th meetings held monthly from March 1985 through January 1986.

The ACRS has previously considered the GE application for an FDA for GESSAR II as it relates to the areas covered in the Standard Review Plan (NUREG-0800). The ACRS letter covering that phase of the review appears in Appendix F to SSER 1.

A copy of the ACRS report on the severe-accident phase of the application dated January 14, 1986, appears as Appendix H to this supplement. A discussion of the current status of each of the items noted in the January 14, 1986, report follows below:

(1) ACRS Comment*

In its policy statement on severe accidents, the Commission did not provide detailed guidance to the staff concerning the safety philosophy the Commission desires for future plants. The requirement for completion of a probabilistic risk assessment (PRA) and of a staff conclusion of safety acceptability leaves the matter of desired safety level undefined and something to be decided ad hoc for each future plant or standard plant design application.

Staff Response

In Section B.3.b of the Severe Accident Policy Statement (50 FR 32138), the Commission specifically addressed the existence of the GESSAR II FDA and the requirements that must be met by the design in order to satisfy the Commission's severe-accident concerns. The Commission acknowledges that the GESSAR II design is suitable for use in new CP and OL applications under certain conditions. The staff's review of GESSAR II concluded that the required conditions were complied with, and that GESSAR II satisfactorily addressed the Commission's severe-accident concerns. It is reasonable to expect that the design will continue to satisfy these concerns as they continue to evolve. Recognizing that very large uncertainties exist in risk predictions (staff estimates of risk disagreed with the corresponding General Electric Co. (GE) estimates by as much as three orders of magnitude in certain areas), the staff and Brookhaven National Laboratory

*Including general comment related to one-step licensing and safety goals.

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(BNL) evaluated GESSAR II using upper-range source terms. The values were believed to be credible but biased toward the upper range, and the staff believes that the corresponding values used by GE are also credible but biased toward the lower end of the expected range. Conservative assumptions were also used in the analysis of the containment failure modes. Nevertheless, even using conservative parameter values, predicted risk levels were still very low as reported in SSER 4. For these reasons, the staff does not believe that future changes in the Commission's severe accident policy or proposed safety goals will result in significant changes in the staff's conclusions regarding GESSAR II.

In its severe-accident policy statement, the Commission acknowledges the importance of scope of design and comprehensive PRAs. Section B.3.b.2. states that "limited scope of plant design and PRA analysis would lead to a partial loss of benefits in that a two-step CP/OL licensing process would be required in lieu of a one-step process." The GESSAR II nuclear island design consists of final design information for the major portion of the BWR/6 plant and Mark III containment. The PRA provided for the design was comprehensive and reflected the current state of the art. Therefore, the staff considers the GESSAR II Final Design Approval suitable for one-step licensing.

(2) ACRS Comment

The applicant and the staff have evaluated the cost/benefit ratio of a large number of potential safety improvements. However, the approach used by the staff is that which has been used in the past and may or may not be that which the Commission will adopt in its continuing consideration of its Safety Goal Policy.

Staff Response

In conducting its severe-accident assessment of the GESSAR II design, the staff's goal was to investigate a wide range of potential design improvements to identify those that provided cost-effective and meaningful reductions in public risk. Quantitative estimates of public risk reduction for the most attractive improvements were developed along with estimates of modification costs. In addition to this offsite cost/benefit evaluation, a separate onsite benefit was determined. These findings were presented in detail within the GESSAR II SSER 4, and were utilized along with other engineering criteria in arriving at the final recommendations regarding implementation of various design improvements.

The cost/benefit approach utilized provided a comprehensive and structured method for evaluating the multitude of design improvements under consideration. Although it is possible that the Commission may modify the approach utilized for cost/benefit analyses in the future, the staff does believe that the techniques utilized provide a strong framework for decisionmaking, and allowed the staff to arrive at prudent recommendations for plant modifications.

(3) ACRS Comment

We believe that further evaluation is needed regarding the likelihood of loss of containment integrity, given an accident leading to melt-through of the reactor pressure vessel. Should this likelihood be large, as the staff says it is, the acceptability of such a characteristic of containment behavior for

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a future plant should have the benefit of a deliberate evaluation, even if the failure is delayed.

- Staff Response

The analysis of the structural integrity of the GESSAR II containment under severe accident loadings was analyzed in more depth than for any previous PRA. Although it was concluded by both GE and the staff that there was a high probability that the containment would eventually fail because of the long-term buildup of pressure from non-condensable gases, it was alsc concluded that the risk contribution from the long-term failures was very small. As reported in SSER 4, the predicted contribution from long-term containment failures accounted for only about 1% of the total public risk from both internal and external events. Further design changes to further reduce or eliminate this contribution are not believed to be justified.

(4) ACRS Comment

The staff proposes to leave the question of seismic risk, including the fragility of equipment within the GESSAR II scope, to the construction permit stage. The staff is confident that some, as yet unspecified, criteria for the seismic contribution to risk of severe accidents can be met at that stage without significant changes in the approved design. We do not share that confidence in the absence of a decision on a safety goal.

- Staff Response

The staff's seismic risk assessment of GESSAR II was not conducted to demonstrate compliance with a bottom-line risk value. Rather, the PRA was a tool utilized to increase understanding of the plant's response to seismic events and to identify weaknesses and vulnerabilities.

The GESSAR II seismic risk is quite dependent on the site chosen and specific equipment installed. The staff's objective in performing the seismic risk assessment was to demonstrate how variations in these factors impact public risk and to identify potential vulnerable areas requiring close attention when an actual GESSAR II plant is sited and built. The potential vulnerable areas identified are: site hazard function, critical components fragility, and relay chatter. Out of these findings came the staff licensing requirements, namely: that an application for a GESSAR II plant demonstrate its site hazard is bounded by that included in the GESSAR II PRA; that critical components and structures have seismic capacities equal to those assumed in the PRA or staff's SER, and finally, that the relay chatter problem be resolved so that it is not a significant risk contributor.

Satisfaction of these conditions would result in a calculated seismic core melt of approximately 2×10^{-5} per year (or less). This is roughly equivalent to the internal event core melt frequency. Further guidance is given that deviations from these requirements should only be considered if it can be demonstrated that adverse public risk does not occur.

Therefore, it is not correct to characterize the staff's actions as leaving the question of seismic risk to the construction permit stage. Rather, through

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detailed analysis, the staff has identified those areas which must be carefully verified when site-specific plant details are available. Attention to these areas will result in the as-built plant corresponding to the risk estimates presented in the staff's SER.

(5) ACRS Comment

The staff consultants were provided only limited resources to review the internal flooding portion of the PRA. Because of the limited effort and the unavailability of design details vital to an evaluation of various flooding scenarios, the consultants were not able to estimate adequately the flooding contribution to core melt, which the applicant calculates to be small. Thus, while some effort was made, the staff's evaluation of the PRA was limited in this respect.

- Staff Response

An important element of the staff's severe-accident assessment was to identify possible areas of uncertainty that might impact the plant's risk profile. This allowed the staff to then establish a process that would respond adequately to the particular problem areas. This process could have involved either further studies during the severe accident evaluation, or identification of necessary actions that could only be reasonably performed on an actual facility. As with elements of the seismic evaluation, the question of internal flooding fell into the second category.

Although the available documentation and design criteria suggested that the internal flooding risk from GESSAR II was quite small, both the staff and its contractor felt that these conclusions were sensitive to possible features of the as-built facility. It was the staff's conclusion that further detailed analyses would not be worthwhile at this time. Rather, the staff identified the necessity of a flooding reassessment when physical details of intercompartment penetrations and door seals can be evaluated. By taking these actions, the staff utilized its PRA insights and findings in a reasoned manner, and assured that a sited GESSAR II facility will not have unacceptable risk contributions from this source.

(6) ACRS Comment

The applicant has committed to incorporate an ultimate plant protection system (UPPS) in the GESSAR II design, which could reduce the incidence of core melt accidents. However, the detailed design of this system has not been provided; it is to be provided at the time of a specific plant application. As a result, the staff has not been able to evaluate this proposed system, nor have we.

- Staff Response

The functional capabilities of the UPPS system as proposed by GE allowed the staff to assess its benefits from a severe accident perspective.

Although detailed design information would have been useful, its lack did not seriously hamper the staff's design improvement evaluation. This evaluation resulted in a number of specific additional requirements for the UPPS system, which were detailed in the staff's SER.

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Detailed design information on UPPS will be reviewed by the staff as a part of a CP submittal for the first plant referencing GESSAR II. ACRS will also have an opportunity to review its design.

(7) ACRS Comment

We are concerned that the scope of the FDA is not defined and documented with sufficient comprehensiveness and detail. We believe that this is necessary in order to make clear what changes in the design or in the plant can subsequently be required by the staff without their being justified under the backfitting rule.

- Staff Response

The GESSAR II Final Design Approval (FDA) will document the scope of the GESSAR II design that has been approved by the staff and the ACRS. The FDA will identify GESSAR II amendments and the SER and its supplements in which the scope of the design has been identified. All areas outside the GESSAR II scope are identified as interfaces in GESSAR II, Section 1.9 and Section 1.10 of the SER and its supplements. Those parts of the design outside the scope are not subject to the provisions of 10 CFR 50.109, the backfitting rule.

(8) ACRS Comment

The interface requirements are not sufficiently well specified in terms of minimum, quantitative performance requirements for systems and components of importance to an evaluation of core melt frequency and risk. Hence, there is no real assurance that a plant built in accordance with the GESSAR II design will meet or better the staff's estimates of accident frequency and consequences.

Also, there is no interface requirement aimed at limiting the number of challenges arising from the balance of plant to those assumed in the PRA.

- Staff Response

The staff does not believe that it is necessary to establish minimum quantitative performance requirements for interfaces in order to complete a meaningful PRA. As indicated previously, the staff's risk assessment of GESSAR II was not conducted to demonstrate a bottom-line risk value. Rather, the PRA was a tool utilized to increase the understanding of the plant response to events and to identify weaknesses and vulnerabilities. The staff does not believe that a plant built to the GESSAR II design must better the staff's estimate of accident frequency and consequences, nor is it necessary that the staff's estimates be met. It will be necessary, however, that utility applicants who reference the GESSAR II design demonstrate that the completed plant design satisfies the assumptions utilized in the design analysis, as well as the PRA analysis. In the event that the assumptions and analyses are not met, the utility applicant must demonstrate that no significant increase in risk results from these changes.

(9) ACRS Comment

We believe that the design of the scram discharge system has basic deficiencies in concept in the form of a preclosed dump volume. Consideration should be

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given to means, which may be relatively simple, to avoid continuing problems with this design.

- Staff Response

The scram discharge system has been discussed at length in past ACRS meetings. It is agreed that improvements could be made; however, the expected benefits in risk reduction have not been found to justify such changes being required for GESSAR II. GESSAR II will have an automatic standby liquid control system. It is in full compliance with the recently published anticipated transient without scram (ATWS) rule. Furthermore, unlike plants with Mark I or Mark II containments, the conditional consequences of an ATWS at GESSAR II with its Mark III containment do not dominate the internal risk profile.

(10) ACRS Comment

We believe that there should be requirements for a study of the effects of seismically induced failures of nonseismically designed components and structures on systems important to safety, for both GESSAR II and the balance of plant.

- Staff Response

The staff has required that certain interface studies relating to seismic effects be completed before issuing a construction permit to a utility referencing the GESSAR II design. These studies will result in a limited understanding of spatial and functional interactions through the plant-specific resolution of Unresolved Safety Issue (USI) A-17 (System Interaction) and the issue of relay chatter. Presently, the staff does not believe that a demonstrated need exists to require additional specific study, for GESSAR II, of the effects of seismically induced failures of non-seismically designed structures and components on systems important to safety. If at a later date the generic resolution of USIs A-17, A-47, and in part A-46 demonstrates the need for further studies relating to the response of the GESSAR II design to seismic events, these studies could be required, provided that they meet the test of 10 CFR 50.109 (backfitting).

(11) ACRS Comment

General Electric maintains that with their choice of materials and proper attention to water quality, GESSAR II should be essentially free of stress corrosion cracking. We do not believe that this can be assumed in view of the long prior history of surprises in regard to stress corrosion cracking. We recommend that any FDA should include provisions for monitoring and for replacement of deficient material.

- Staff Response

The GESSAR II design incorporates the use of intergranular stress corrosion cracking (IGSCC) resistant material and also will use hydrogen-water chemistry for the reactor coolant. The staff has concluded that this combination will certainly reduce the probability of stress corrosion cracking to low levels.

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Any GESSAR II plant would be required to perform inservice inspection in accordance with ASME Boiler and Pressure Vessel Code requirements. The staff concludes that performing these required inspections will provide the necessary monitoring to ensure against unanticipated cracking mechanisms. The staff has not identified any design features that would preclude replacement of material or components if this should be found to be necessary.

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APPENDIX A

CONTINUATION OF CHRONOLOGY

June 10, 1985	Letter from General Electric Co. (GE) transmitting information on the resolution of the open item concerning clutter on the GE emergency response information system.
June 18, 1985	Letter to GE requesting that proposed Safety Evaluation Report be reviewed for proprietary information.
June 25, 1985	Letter from GE identifying proprietary information in the Safety Evaluation Report.
July 24, 1985	Letter to GE transmitting Supplement 4 to NUREG-0979 (SSER 4).
August 9, 1985	Letter to GE transmitting Amendment 1 to Final Design Approval (FDA-1) and Federal Register Notice of issuance. Amendment removes constraint on forward referenceability of GESSAR II design and permits reference in new construction permit (CP) and operating license (OL) applications.
August 12, 1985	Letter from GE transmitting proprietary Supplement I to draft of GESSAR II amendment supporting leak before break.
September 5, 1985	Letter from GE acknowledging receipt of August 6, 1985, Advisory Committee on Reactor Safeguards (ACRS) memorandum on severe-accident review.
October 9, 1985	Letter to GE transmitting "Review of BWR/6 Standard Plant Probabilistic Risk, Assessment, Volume 2: Seismic Events, Core Damage Frequency and Containment Event Tree Analysis" from Brookhaven National Laboratory.
October 28, 1985	Letter from GE acknowledging receipt of telecopy regarding proposed revision to NRC definition of Final Design Approval presented at September 12, 1985, ACRS full-Committee meeting and stating that proposed revisions are acceptable.
October 30, 1985	Letter from GE transmitting marked-up copy of proprietary "Review of BWR/6 Standard Plant Probabilistic Risk Assessment, Volume 2: Seismic Events, Core Damage Frequency and Containment Event Tree Analysis" in response to October 9, 1985, request.

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January 22, 1986	Letter to GE transmitting for review and comment the ACRS report regarding concerns of the Commission's severe-accident policy statement.
February 4, 1986	Letter from GE transmitting comments on ACRS report.
April 25, 1986	Letter from GE transmitting GESSAR II Amendment 21.

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APPENDIX E

PRINCIPAL STAFF CONTRIBUTORS

U.S. NUCLEAR REGULATORY COMMISSION*

Name	Branch (Division)**
W. B. Hardin	Reliability & Risk Assessment (Safety Review & Oversight)
M. Rubin	Facility Operations (PWR Licensing B)
D. Scaletti	Standardization and Special Projects Directorate (PWR Licensing B)

*Office of Nuclear Reactor Regulation (NRR), except where noted.

**Reflects NRR reorganization since SSER 4 was issued.

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APPENDIX G

COMPLIANCE WITH CP/ML RULE (10 CFR 50.34(f))

Item (2)(iv)

- Discussion

(3) Evaluation

(h) System Reliability

In Appendix G to SSER 4, Item (2)(iv), the staff identified one issue, which it considered confirmatory in nature, related to safety parameter display system (SPDS) reliability. On the basis of further consideration of this issue, the staff believes that additional review of system reliability of the GESSAR II SPDS is not necessary at this time.

NUREG-0737, Supplement 1, requires that the SPDS should continuously display information from which the plant safety status can be readily and reliably assessed. The SPDS need not meet single-failure criteria and it need not be qualified to meet Class 1E requirements. NUREG-0737, Supplement 1, recognizes that there will be periods when the SPDS will not be available for use, by requiring that operators be trained to respond to accident conditions with and without the SPDS available.

It is the staff's conclusion that at this time the GESSAR II SPDS provides the necessary reliability to satisfy the requirements specified in Supplement 1 to NUREG-0737 and that any further system reliability review will be conducted concurrently with the staff audit of the plant-specific implementation program of the utilities that reference the GESSAR II SPDS, if it is considered necessary at that time.

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APPENDIX H

ACRS REPORT RELATED TO THE FINAL DESIGN APPROVAL OF THE GESSAR II BWR/6 NUCLEAR ISLAND DESIGN APPLICABLE TO FUTURE PLANTS

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UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, D. C. 20555

January 14, 1986

Honorable Nunzio J. Palladino
Chairman
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Dear Dr. Palladino:

SUBJECT: ACRS REPORT RELATED TO THE FINAL DESIGN APPROVAL OF THE GESSAR II BWR/6 NUCLEAR ISLAND DESIGN APPLICABLE TO FUTURE PLANTS

During its 309th meeting, January 9-11, 1986, the Advisory Committee on Reactor Safeguards completed a review of the reference design described in the General Electric Standard Safety Analysis Report (GESSAR II) for a Final Design Approval (FDA). GESSAR II provides the safety information for a reference system consisting of a single BWR/6 Mark III nuclear steam supply system, with a design power level of 3730 MWt, and associated systems and structures, including the reactor building (the shield building and containment), fuel building, diesel generator buildings, control building, auxiliary building, and radwaste building. Subcommittee meetings were held with representatives of the General Electric Company (the Applicant) and the Nuclear Regulatory Commission (NRC) Staff on October 18-19, December 4-5, 1984, and February 14-15, 1985 in Los Angeles, Calif.; on March 27-29, 1985, in Albuquerque, New Mexico; and on August 7 and September 11, 1985 in Washington, D. C. The full Committee considered this matter during its 299th through 309th meetings held monthly from March 1985 through January 1986.

We believe that the GESSAR II design includes features that provide a significant improvement in safety over current BWR designs. If this were an application for a construction permit for one or more plants of this design, we would have no hesitation in recommending its approval. However, we are unable to agree with the Staff, for reasons discussed below, that the design satisfactorily or completely addresses all of the concerns described in the Commission's Severe Accident Policy.

While there is no doubt that, in the future, new plants should be consistent with the Severe Accident Policy, we see no harm in the approval of the GESSAR II design, provided that this approval is for a limited time (say five years), and provided that this procedure not be viewed in any way as a precedent for the handling of future applications. In particular, the information provided to us in connection with GESSAR II would not be sufficient to support an application for a one-step license.

Our concerns about the review and the review process are elaborated in the following paragraphs.

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We believe that reviewing the GESSAR II design under the Severe Accident Policy was premature and incomplete. We do not see how the Severe Accident Policy can be implemented for an FDA while the policy on safety goals is still in the process of being developed. The NRC Staff's severe accident review of the GESSAR II design was based on the acceptance of values of core-damage probability and the use of cost/benefit analyses that may turn out to be quite different from those adopted by the Commission for implementation of the safety goals. These and other concerns are discussed in the following items:

- In its policy statement on severe accidents, the Commission did not provide detailed guidance to the Staff concerning the safety philosophy the Commission desires for future plants. The requirement for completion of a PRA and of a Staff conclusion of safety acceptability leaves the matter of desired safety level undefined and something to be decided ad hoc for each future plant or standard plant design application.

- The Applicant and the Staff both evaluated the cost/benefit ratio of a large number of potential safety improvements. However, the approach used by the Staff is that which has been used in the past and may or may not be that which the Commission will adopt in its continuing consideration of its Safety Goal Policy.

- We believe that further evaluation is needed regarding the likelihood of loss of containment integrity, given an accident leading to melt-through of the reactor pressure vessel. Should this likelihood be large, as the Staff says it is, the acceptability of such a characteristic of containment behavior for a future plant should have the benefit of a deliberate evaluation, even if the failure is delayed.

- The Staff proposes to leave the question of seismic risk, including the fragility of equipment within the GESSAR II scope, to the construction permit stage. The Staff is confident that some, as yet unspecified, criteria for the seismic contribution to risk of severe accidents can be met at that stage without significant changes in the approved design. We do not share that confidence in the absence of a decision on a safety goal.

- The Staff consultants were provided only limited resources to review the internal flooding portion of the PRA. Because of the limited effort and the unavailability of design details vital to an evaluation of various flooding scenarios, the consultants were not able to estimate adequately the flooding contribution to core melt, which the Applicant calculates to be small. Thus, while some effort was made, the Staff's evaluation of the PRA was limited in this respect.

Our concerns about the FDA process include chiefly two areas: (1) the amount of detail and completeness required for approval of a "final

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design" and (2) the nature and definition of the interfaces between the nuclear island and the balance of plant, especially those that must be expressed in terms of reliability to meet the intent of the Severe Accident Policy. These concerns are generic to the standard plant concept and have arisen in our deeper examination of GESSAR II in terms of the Severe Accident Policy. Their resolution necessarily will be evolutionary; but, in our opinion they have not been adequately resolved in the GESSAR II application and review. Some of our concerns are described more fully in the following:

- The Applicant has committed to incorporate an ultimate plant protection system (UPPS) in the GESSAR II design, which could reduce the incidence of core melt accidents. However, the detailed design of this system has not been provided; it is to be provided at the time of a specific plant application. As a result, the Staff has not been able to evaluate this proposed system, nor have we.

- We are concerned that the scope of the FDA is not defined and documented with sufficient comprehensiveness and detail. We believe that this is necessary in order to make clear what changes in the design or in the plant can subsequently be required by the Staff without their being justified under the backfitting rule.

- The interface requirements are not sufficiently well specified in terms of minimum, quantitative performance requirements for systems and components of importance to an evaluation of core melt frequency and risk. Hence, there is no real assurance that a plant built in accordance with the GESSAR II design will meet or better the Staff's estimates of accident frequency and consequences. Also, there is no interface requirement aimed at limiting the number of challenges arising from the balance of plant to those assumed in the PRA.

Over and above the questions relating to the severe accident review and adequacy of the FSAR for an operating license stage document, the ACRS thinks that the following matters warrant consideration for the GESSAR II.

- We believe that the design of the scram discharge system has basic deficiencies in concept in the form of a preclosed dump volume. Consideration should be given to means, which may be relatively simple, to avoid continuing problems with this design.

- We believe that there should be requirements for a study of the effects of seismically induced failures of nonseismically designed components and structures on systems important to safety, for both GESSAR II and the balance of plant.

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- General Electric maintains that with their choice of materials and proper attention to water quality, GESSAR II should be essentially free of stress corrosion cracking. We do not believe that this can be assumed in view of the long prior history of surprises in regard to stress corrosion cracking. We recommend that any FDA should include provisions for monitoring and for replacement of deficient material.

Our findings and recommendations are as follows:

- We believe that the GESSAR II design includes features that have the potential to provide a significant improvement in safety over current BWR designs.

- We are unable to agree with the Staff, for reasons discussed previously, that the design satisfactorily or completely addresses all of the concerns described in the Commission's Severe Accident Policy Statement.

- We see no harm in the approval of the GESSAR II design, provided that this approval is for a limited time (say five years), and provided that this procedure not be viewed in any way as a precedent for the handling of future applications. In particular, the information provided to us in connection with GESSAR II would not be sufficient to support an application for a one-step license.

Additional comments by ACRS members Max W. Carbon and Charles J. Wylie and by ACRS Member David Okrent are presented below.

Sincerely,

David A. Ward

David A. Ward
Chairman

Additional Comments by ACRS Members Max W. Carbon and Charles J. Wylie

It is our belief that the GESSAR II design represents an improvement in safety over BWR designs approved in the past and that the Applicant has met all NRC requirements. Many items remain open to final resolution, but considerable additional review will be performed by both the Staff and the ACRS for either one- or two-step licensing. Therefore, we support the Staff's plan to issue an FDA applicable to one-step licensing.

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Additional Comments by ACRS Member David Okrent

I agree with the ACRS that the GESSAR II design (and NRC Staff review) does not satisfactorily or completely address all of the concerns described in the Commission's Severe Accident Policy Statement. I also agree with those specific concerns about the review and review process described in the ACRS report.

I do not concur with the Staff that the design and review are adequate for issuance of an FDA that has met the Severe Accident Policy Statement, one which, according to the EDO recommended position, would be eligible for a five-year extension after a five-year initial award (and one for which the AIF proposes a ten-year approval period). I would have preferred rather that this be an interim report and that the entire matter, including the status of the GESSAR II review, be discussed by the ACRS with the Commissioners prior to further action on the GESSAR II FDA. In view of the multiple problems of inadequate design detail, incomplete Staff review, and potential conflicts with safety goal policy, among others, I do not think that GESSAR II should receive the "qualified" FDA recommended by the ACRS at this time.

I would like to elaborate on some of the concerns raised in the ACRS letter and introduce others that are not mentioned in the ACRS letter, as follows:

1. The seismic design and seismic PRA are inadequately defined. In SSER No. 3, the Staff determined that the GESSAR II seismic risk study did not model well the risk likely to be contributed by seismic initiators for an actual GESSAR II plant at a typical site. The Staff now reports that the point estimate seismic-induced core melt frequency might be as high as one-in-a-thousand per year for "worst case" fragility values and unfavorable siting locations. The Staff gives a point estimate of about $4\text{-}5 \times 10^{-5}$ per year as the seismic contribution to core melt frequency, perhaps half of which is attributed to seismically induced relay chatter. The Staff's estimate of the seismic contribution to core melt frequency is not a mean value, and it is not practical to ascertain a mean from their reported results.

   I am currently not able to ascribe a numerical value to the seismic contribution to risk. However, I believe that the Staff estimate of about $4\text{-}5 \times 10^{-5}$ is too large to be accepted for the contribution to core melt frequency from a single source or kind of accident initiator. I believe this value is too large an overall core melt frequency to be accepted for a future plant or FDA. I recommend that an overall total large-scale core melt frequency with a mean value of 10^{-5} per year be taken as the objective for future plants, and that about one-fifth of this objective should be a somewhat flexible objective for any principal contributor, such as an earthquake. Limitations on the contribution from individual sources will help reduce the impact of large uncertainties.

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The Staff proposes to leave the question of seismic risk, including the fragility of components and equipment within the GESSAR II scope, to the construction permit stage. The Staff lists conditions to be met which could be interpreted as accepting a seismic core melt frequency such as the Staff estimates. The Staff further concludes that, if these conditions are not met, the utility applicant must demonstrate that this does not result in any significant increment in risk. But what is significant for a PRA? Is it a factor of two? A factor of ten? The Staff provides no basis for judging what might be acceptable in this regard. The Staff also states that the site hazard curve must be bounded by the GESSAR II hazard curve, without explaining how uncertainties are to enter into such a bounding exercise.

Although GESSAR II is well into the design stage, I believe that the merits of probabilistic seismic design bases should receive consideration in trying to achieve a smaller contribution to overall risk.

2. I believe that the FDA should not be approved with such incomplete and sketchy information available for the proposed ultimate plant protection system (UPPS).

3. For future plants, I believe that a dedicated, safety-grade, independent system for removal of decay heat from the core and containment should be included, in consequence of the matters entering into the resolution of USI A-45, Shutdown Decay Heat Removal, unless a case can be made that all of its merits have been met in other ways. I favor hardening this system. This issue is discussed further in the next item.

4. In its review of GESSAR II, the Staff did not look beyond the current requirements for sabotage protection. In a letter to you dated July 17, 1985 concerning sabotage protection, the ACRS recommended that the Commission reconsider its design basis threat definition for sabotage protection and decide if the present definition should be reconfirmed or modified. The Committee also recommended that the Commission consider whether the NRC Staff, in the course of reviews of new designs, should take account of design options, and possible combinations of measures, which might have the effect of reducing or inhibiting sabotage or terrorist threats. This matter should be dealt with before issuance of future FDAs, rather than as a possible backfit item. Specifically, I recommend that the following be factored into the design of GESSAR II (and its balance of plant):

   . a protected, independent, safety-grade shutdown heat removal system

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- protection of the control room and other vital areas or functions against a vehicle bomb at the edge of the guarded site periphery by proper location, building strength, or other measures
- geographical separation of redundant systems, including the ultimate heat removal system
- special monitoring and access control of especially sensitive protection systems
- roof design to limit helicopter landing access

In summary, I believe that neither the state of the design nor the Staff's review process is adequate for issuance of a forward-looking FDA which has taken Severe Accident and Safety Goal Policy properly into account. This is particularly so in view of the Commission's own test in applying backfitting policy.

References:

1. General Electric Company Standard Safety Analysis Report, "GESSAR II, BWR/6 Nuclear Island Design," with Amendments 1 through 20
2. U. S. Nuclear Regulatory Commission, "Safety Evaluation Report Related to the Final Design Approval of the GESSAR II BWR/6 Nuclear Island Design" NUREG-0979, dated April 1983
3. Supplement 1 to the Safety Evaluation Report, dated July 1983
4. Supplement 2 to the Safety Evaluation Report, dated November 1984
5. Supplement 3 to the Safety Evaluation Report, dated January 1985
6. Supplement 4 to the Safety Evaluation Report, dated July 1985

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13. ABSTRACT (200 words or less)

Supplement 5 to the Safety Evaluation Report (SER) for the application filed by General Electric Company for the final design approval for the GE BWR/6 nuclear island design (GESSAR II) has been prepared by the Office of Nuclear Reactor Regulation of the Nuclear Regulatory Commission. This report supplements the GESSAR II SER (NUREG-0979) issued in April 1983 summarizing the results of the staff's safety review of the GESSAR II BWR/6 nuclear island design; Supplement 1, issued in July 1983; Supplement 2, issued in November 1984; Supplement 3, issued in January 1985; and Supplement 4, issued in July 1985. Subject to favorable resolution of the items discussed in the Final Design Approval FDA-1, Amendment No. 2) the staff concludes that the GESSAR II design satisfactorily addresses the severe-accident concerns described in the Commission's Policy Statement on Severe Reactor Accidents Regarding Future Designs and Existing Plants, and that subject to the approval of the balance-of-plant design, applicants referencing GESSAR II can conform with provisions of the Atomic Energy Act of 1954, as amended and the regulations of the Nuclear Regulatory Commission.

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